

AMENDMENTS TO THE CLAIMS

Following is a listing of all claims in the present application, which listing supersedes all previously presented claims:

Listing of Claims:

1. (Currently Amended) A fluxgate sensor, comprising:

a soft magnetic core formed on a semiconductor substrate;

an excitation coil, the excitation coil winding the soft magnetic core and being insulated by first and second insulating layers deposited above and below the soft magnetic core, respectively;

a pick-up coil, the pick-up coil winding the soft magnetic core and being insulated by third and fourth insulating layers deposited above and below the excitation coil, respectively; and

along a direction substantially perpendicular to the semiconductor substrate, overlapping portions of the pick-up coil overlapping with and sandwiching overlapping portions of the excitation coil and a portion of the soft magnetic core extending substantially parallel to the semiconductor substrate between the overlapping portions of the excitation coil and the pick-up coil. ~~at least a portion of one of the excitation coil and the pick-up coil being sandwiched between the soft magnetic core and the other one of the excitation coil and the pick coil.~~

2. (Currently Amended) The fluxgate sensor as claimed in claim 1, wherein the soft magnetic core comprises two parallel bars each disposed on a same plane that is substantially parallel to the semiconductor substrate.

3. (Previously Presented) The fluxgate sensor as claimed in claim 2, wherein the two parallel bars are aligned to have a length dimension in a direction of magnetic field detection.

4. (Original) The fluxgate sensor as claimed in claim 3, wherein the excitation coil has a structure of alternately winding the two parallel bars substantially in a figure-eight pattern.

5. (Original) The fluxgate sensor as claimed in claim 4, wherein the pick-up coil has a structure of winding the two parallel bars together substantially in a solenoid pattern.

6. (Original) The fluxgate sensor as claimed in claim 4, wherein the pick-up coil has a structure of individually winding the two parallel bars substantially in a solenoid pattern.

7. (Original) The fluxgate sensor as claimed in claim 3, wherein the excitation coil has a structure of individually winding the two parallel bars substantially in a solenoid pattern.

8. (Original) The fluxgate sensor as claimed in claim 7, wherein the pick-up coil has a structure of winding the two parallel bars together substantially in a solenoid pattern.

9. (Original) The fluxgate sensor as claimed in claim 7, wherein the pick-up coil has a structure of individually winding the two parallel bars substantially in a solenoid pattern.

10. (Original) The fluxgate sensor as claimed in claim 1, wherein the soft magnetic core is formed in a rectangular-ring type.

11. (Original) The fluxgate sensor as claimed in claim 10, wherein the rectangular ring is oriented to have a length dimension in a direction of magnetic field detection.

12. (Original) The fluxgate sensor as claimed in claim 11, wherein the excitation coil has a structure of alternately winding two opposite sides of the rectangular ring aligned in the direction of magnetic field detection substantially in a figure-eight pattern.

13. (Original) The fluxgate sensor as claimed in claim 12, wherein the pick-up coil has a structure of winding two opposite sides of the rectangular ring aligned in the direction of magnetic field detection together substantially in a solenoid pattern.

14. (Original) The fluxgate sensor as claimed in claim 12, wherein the pick-up coil has a structure of individually winding two opposite sides of the rectangular ring aligned in the direction of magnetic field detection substantially in a solenoid pattern.

15. (Original) The fluxgate sensor as claimed in claim 11, wherein the excitation coil has a structure of individually winding two opposite sides of the rectangular ring aligned in the direction of magnetic field detection substantially in a solenoid pattern.

16. (Original) The fluxgate sensor as claimed in claim 15, wherein the pick-up coil is deposited on the excitation coil, and has a structure of winding two opposite sides of the rectangular ring aligned in the direction of magnetic field detection together substantially in a solenoid pattern.

17. (Original) The fluxgate sensor as claimed in claim 15, wherein the pick-up coil is deposited on the excitation coil, and has a structure of individually winding two opposite sides of the rectangular ring aligned in the direction of magnetic field detection substantially in a solenoid pattern.

18. (Original) A method for manufacturing a fluxgate sensor, comprising:
forming a lower portion of a pick-up coil on an upper surface of a semiconductor substrate;
depositing a first insulating layer on the upper surface of the semiconductor substrate, in which the lower portion of the pick-up coil is formed, and forming a lower portion of an excitation coil at a position corresponding to the pick-up coil;
depositing a second insulating layer on an upper surface of the lower portion of the excitation coil, and forming a plurality of first via holes electrically connected with the lower portion of the excitation coil;
forming a soft magnetic core on an upper portion of the second insulating layer having the first via holes formed therein, to correspond in arrangement with the pick-up coil and the excitation coil;

depositing a third insulating layer on an upper portion of the soft magnetic core, and forming a plurality of second via holes electrically connected with the lower portion of the excitation coil;

forming an upper portion of the excitation coil at a position corresponding to the lower portion of the excitation coil on an upper surface of the third insulating layer having the plurality of second via holes formed therein, the upper portion of the excitation coil being electrically connected with the lower portion of the excitation coil;

depositing a fourth insulating layer on the upper portion of the excitation coil and forming a plurality of third via holes electrically connected with the lower portion of the pick-up coil; and

forming an upper portion of the pick-up coil corresponding to the lower portion of the pick-up coil on the upper portion of the fourth insulating layer having the plurality of third via holes formed therein, the upper portion of the pick-up coil being electrically connected with the lower portion of the pick-up coil.

19. (Original) The method as claimed in claim 18, wherein forming the lower portion of the pick-up coil comprises:

forming a plurality of trenches in the upper surface of the semiconductor substrate, the plurality of trenches having a high rate of section area and small pitch size;

depositing by vacuum evaporation a seed layer on the upper surface of the semiconductor substrate having the plurality of trenches formed therein;

plating the upper surface of the semiconductor substrate having the seed layer deposited thereon; and

polishing the upper surface of the semiconductor substrate to insulate the metal filling each of the plurality of trenches from one another.

20. (Original) The method as claimed in claim 18, wherein forming the lower portion of the pick-up coil comprises:

- depositing a seed layer on the upper surface of the semiconductor substrate;
- applying a photosensitive material on an upper portion of the seed layer, and forming a plating flask through exposure and developing;
- plating through the plating flask; and
- removing the plating flask.

21. (Original) The method as claimed in claim 18, wherein each of forming the lower portion of the excitation coil, forming the upper portion of the excitation coil, and forming the upper portion of the pick-up coil comprises:

- applying a photosensitive material on an exposed upper surface of the previously applied insulating layer;
- forming a pattern using an exposure with respect to the photosensitive material;
- forming a plating flask by etching the photosensitive material in accordance with the pattern;
- forming a seed layer on the upper surface of the semiconductor substrate in which the photosensitive material is etched in accordance with the pattern;
- plating the substrate in which the seed layer is formed;

polishing the upper surface of the semiconductor substrate to insulate the metal filling the etched area; and

removing the plating flask from the semiconductor substrate.

22. (Original) The method as claimed in claim 18, wherein each of forming the lower portion of the excitation coil, forming the upper portion of the excitation coil and forming the upper portion of the pick-up coil comprises:

depositing a seed layer on an exposed upper surface of the previously applied insulating layer;

applying a thick photoresist on an upper portion of the seed layer;

forming a pattern using an exposure with respect to the thick photoresist;

forming a plating flask by etching along the pattern;

plating through the plating flask; and

polishing the upper surface of the semiconductor substrate to insulate the metal filling the etched area; and

removing the plating flask and the seed layer at a lower portion of the plating flask from the semiconductor substrate.

23. (Original) The method as claimed in claim 18, wherein the soft magnetic core comprises two parallel bars disposed in a same plane.

24. (Original) The method as claimed in claim 23, wherein the two parallel bars have are aligned to have a length dimension in a direction of magnetic field detection.

25. (Original) The method as claimed in claim 24, wherein the excitation coil has a structure of alternately winding the two parallel bars substantially in a figure-eight pattern.

26. (Original) The method as claimed in claim 25, wherein the pick-up coil is formed on the excitation coil and has a structure of winding the two parallel bars together substantially in a solenoid pattern.

27. (Original) The method as claimed in claim 25, wherein the pick-up coil is formed on the excitation coil and has a structure of individually winding the two parallel bars substantially in a solenoid pattern.

28. (Original) The method as claimed in claim 24, wherein the excitation coil has a structure of individually winding the two parallel bars substantially in a solenoid pattern.

29. (Original) The method as claimed in claim 28, wherein the pick-up coil is formed on the excitation coil and has a structure of winding the two parallel bars together substantially in a solenoid pattern.

30. (Original) The method as claimed in claim 28, wherein the pick-up coil is formed on the excitation coil and has a structure of individually winding the two parallel bars substantially in a solenoid pattern.

31. (Original) The method as claimed in claim 18, wherein the soft magnetic core is formed in a rectangular-ring type.

32. (Original) The method as claimed in claim 31, wherein the rectangular ring is oriented to have a length dimension in a direction of magnetic field detection.

33. (Original) The method as claimed in claim 32, wherein the excitation coil has a structure of alternately winding two opposite sides of the rectangular-ring substantially in a figure-eight pattern.

34. (Original) The method as claimed in claim 33, wherein the pick-up coil has a structure of winding two opposite sides together substantially in a solenoid pattern.

35. (Original) The method as claimed in claim 33, wherein the pick-up coil is formed on the excitation coil and has a structure of individually winding two opposite sides substantially in a solenoid pattern.

36. (Original) The method as claimed in claim 32, wherein the excitation coil has a structure of individually winding two opposite sides substantially in a solenoid pattern.

37. (Original) The method as claimed in claim 36, wherein the pick-up coil is formed on the excitation coil and has a structure of winding two opposite sides together substantially in a solenoid pattern.

38. (Original) The method as claimed in claim 36, wherein the pick-up coil is formed on the excitation coil and has a structure of individually winding two opposite sides substantially in a solenoid pattern.